IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: MIYAMOTO, et al.

Group Art Unit: 3745

Serial No.: 09/473,137

Examiner: C. Verdier

Filed: December 28, 1999

P.T.O. Confirmation No.: 9634

For. TURBO-MOLECULAR PUMP

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
Washington, D.C. 20231

Sir:

The undersigned, Matsutaro MIYAMOTO , is one of the applicants in the above-identified U.S. patent application and herein declares:

1. That I graduated from the National Defense Academy in Japan and majored in mechanical engineering.

That I have been employed for fourteen years in Ebara Corporation, which is located in 11-1, Haneda Asahi-cho, Ohta-ku, Tokyo, 144-8510, Japan. As an engineer, I have been involved in developing turbo-molecular pumps for thirteen years.

2. Necessity of the present invention

The present invention relates to a turbo-molecular pump which rotates at a high speed, and an object of the present invention is to provide a turbo-molecular pump which can

ensure safety when an abnormal torque is generated and transmitted from the rotor to the stator.

Attached is the technical document "Development of a Large Capacity Turbomolecular Pump (Ebara Review No. 196 Excerption)" written by the Inventor and related to the development of a product to which the present invention is applied.

As shown in the attached data, the conventional turbo-molecular pump faces a technical problem in that an abnormal torque may be generated and transmitted from the rotor to the stator.

When such an abnormal torque is generated and transmitted from the rotor to the stator, not only the pump casing and the stator are adversely affected, but pipes connecting to devices outside of the pump may also be adversely affected, such as being damaged or fractured.

Generally, in a semi-conductor manufacturing equipment, turbo-molecular pump is used to process gases, which gases can be harmful once they come in contact with people. Any damage or fracture of the pump and components can be dangerous because processing gases may be released to the environment.

In addition, such damage or fracture of the pump and related components may cause a leak to the sealed environment of the semi-conductor manufacturing equipment under vacuum and may cause damage to the equipment and products under manufacture.

Furthermore, any damage and fracture at a place where the turbo-molecular pump is attached to the equipment may cause the pump body to fall off from the equipment, resulting

in damage to nearby properties and bystanders.

On the other hand, the size of the semi-conductor manufacturing equipment has been under strong market demand to be downsized, thus further shrinking the amount of adequate space for the turbo-molecular pump to be installed.

There is a perpetual problem in that the larger the pump scale becomes, the stronger the market is for downsizing and the smaller the amount of adequate space for installation. Therefore, there is an ever increasing need to incorporate greater safety features into the pumps.

As the pump scale becomes larger, the rotational energy of the rotor increases and an abnormal torque once being generated becomes larger.

With this background, the safety measures described in the present invention have been strongly desired in the marketplace.

3. Summary of the present invention/Solution that the present invention might provide

The following is the process through which the Inventor tackled the abovementioned issues, or how to establish the safety measure to minimize the effect of an abnormal torque which is generated and transmitted from the rotor to the stator of the turbo-molecular pump.

As one of many safety measures, the Inventor originated a method to reduce the torque generated and transmitted from the rotor to the stator, wherein the stator rotates inside the pump casing. As the stator rotation consumes the rotor's rotational energy, torque

generated by the rotor is decreased.

The Inventor made an assumption that setting the stator free from the pump casing first is necessary to rotate the stator; thus, the Inventor invented the constriction releasing structure.

To rotate the stator after releasing constriction, the Inventor made an assumption that it would be effective to reduce friction between the pump casing and the stator as much as possible.

However, as written in the attached document, the impact force to the stator upon the rotor breakdown is quite large and can become a momentary and excessive impact force.

Thus, even if the structure is modified from the aspect of the stator rotation against the pump casing, the large impact force can generate a large frictional force between the pump casing and the stator and eventually disturbs the stator rotation. The Inventor has found this fact through repeated performance of basic tests.

4. Significance of the clearance in the present invention

Based on a basic idea that friction is a phenomenon caused by having an object being in contact with another object, the Inventor defined a state in which objects do not come in contact with each other as an ultimate non-friction state. Then, the Inventor originated an idea to create a clearance between the pump casing and the stator where no objects are in contact with one another.

In addition, the Inventor made an assumption that the clearance would be effective to

prevent the momentary and excessive impact force from being transmitted from the stator to the pump casing.

The Inventor also assumed that the clearance would become an effective space to release constriction in the constriction releasing structure.

Next, to determine the optimal size of the clearance, the Inventor originated a concept of an impact absorbing structure, which structure absorbs impact force, wherein the clearance between the pump casing and the stator can be maintained even when such an excessive impact force is received upon a rotor breakdown, thus minimizing transmission of the impact, and decreasing friction as much as possible.

Also, the clearance and adopting a part of the rotational system of the stator to the pump casing have ensured that the stator would rotate against the pump casing.

As described above, the initial purpose to reduce the generated torque from the rotor to the stator by rotating the stator inside of the pump casing has been accomplished by inventing the clearance between the pump casing and the stator.

Thus, the clearance created in the present invention is fundamentally significant and groundbreaking.

5. Comparison with prior arts

As described above, the clearance in the present invention is fundamentally different from those described in the prior art. Details will be described below.

- Prior art example 1. German Patent 2,214,702

- Prior art example 2. German Patent 3,402,549

Clearances described in both prior art examples are created for the necessity of the manufacturing process and cost reduction by not being concerned with machining accuracy.

- Prior art example 3. Deters 4,797,062

A clearance described in this example is created for preventing heat transmission caused by being in contact with each other.

Thus, all clearances in the examples described above are created from the static point of view, focusing on the structure.

In contrast, the clearance of the present invention is created by the dynamic point of view of focusing on the impact and frictional forces being generated and transmitted from the rotor, which rotates at a high speed, to the stator upon an abnormal torque generation. That is, the clearance in the present invention is different in nature from the clearances provided in the prior art examples.

Although both the present invention and the prior art examples have a clearance between the pump casing and the stator, creation of the clearance in the present invention comes from paying attention to behaviors of each component and parts inside of the pump casing when an abnormal torque is generated and transmitted from the rotor to the stator.

In other words, the clearance in the present invention is intended to reduce the impact and frictional forces, which are transmitted regardless of whether the stator is in contact with the pump casing or not, and eventually to reduce the impact force and torque transmission to the pump casing upon rotor failure, and its effect is more properly and securely appreciated

by the stator's constriction releasing structure and rotational system. The clearance should be distinguished from those described in other prior arts.

In the prior art examples, when an abnormal torque is generated and transmitted from the rotor to the stator, a part of the clearance between the pump casing and the stator is surely and immediately lost, causing the stator to come in contact with the pump casing, stopping the stator rotation against the pump casing, thus transmitting an excessive torque caused by the impact and frictional forces to the pump casing, eventually damaging or fracturing not only the pump casing itself but also any pipes connecting to any equipment outside of the pump.

In addition, the prior art examples have no description about the purpose set in the present invention, that is, to reduce the impact force and torque transmission to the pump casing when an abnormal torque is generated and transmitted from the rotor to the stator; therefore, it is obvious that they do not teach or suggest the present invention.

- Related art example 4. Japanese Patent 59-153,988

This prior art is related to an "installation device" for a vacuum rotational machine (embodiment: turbo-molecular pump), not a turbo-molecular pump itself equipped with an exhaustion function.

Actually, Fig. 2 shows that the vacuum rotational machines 14 (embodiment: turbo-molecular pump 30) are connected so that the exhaust paths are aligned in series, and are installed inside of the installing housing 10.

The suction pipe 50, which is connected to these multiple vacuum rotational machines

14 and the vacuum container 5 to be evacuated and located outside, is led to the suction chamber 42 formed in the upper lid 12 of the installing housing 10.

Similarly, the exhaust pipe 51, which communicates with the exhaust chamber 46 formed in the upper lid 12 of the installing housing 10, is connected to other vacuum machines, such as a roughing pump, equivalent to reference numeral 8 in Fig. 1.

The exhaust path from suction to exhaustion comprises only the upper lid 12 and the vacuum rotational machines 14, and does not exist in a space which is formed by the inside of the installing housing 10 and the outside of the vacuum rotational machines 14 and is pointed out by the Examiner.

This space is evacuated through the exhaust pipe 22 by another pump (negative pressure source), which is different from the above exhaust path, and the space is maintained at the negative pressure.

According to this structure, the installing housing 10 is not capable of functioning as a vacuum pump, and does not have any exhaust path which allows the interior space of the installing housing 10 to be exhausted by itself.

In this prior art example, the vacuum pump or turbo-molecular pump is definitely the vacuum rotational machine 14 installed in the installing housing 10.

In addition, the pump casing of this vacuum rotational machine is shown by reference numeral 25.

Also, the stator of this vacuum rotational machine is shown by reference numeral 31.

Therefore, this prior art example does not disclose a clearance between the pump

casing and the stator, but discloses a space between the installing housing 10 and the pump casing 25.

In contrast, the present invention has an object to reduce the impact force and the torque transmission to the pump casing when an abnormal torque is generated and transmitted from the rotor to the stator, and is structured so that the object can be accomplished only inside the pump body or pump casing by creating the clearance between the pump casing and the stator; thus, the clearance of the present invention is intrinsically different from those of the prior art.

- Related art example 5. Japanese Patent 6-40954

Japanese patent 6-40954 (JP6-40954) discloses that stator (3b) of a spiral groove vacuum pump section (3) is provided slidably in a circumferential direction in housing (1) to solve a problem C described hereinbelow under conditions A and B (quoted from JP6-40954 (which corresponds to JP1-113191) and translated into English).

Conditions

(A) "According to a spiral groove vacuum pump, in view of its discharge principle, a clearance between an outer surface of a rotor and an inner surface of a stator is generally extremely narrow such as from 0.2 to 1.0 mm at a minimum portion thereof."

(B) "Further, mass of the rotor can reach several times as much as that of a rotor of a turbo-molecular pump having the same outer diameter and is rotated at high speed at several ten thousands rotations per minute."

Problem

(C) "However, according to the conventional spiral groove vacuum pump, as described above, stator (d) is fixed in housing (a). In the worst case in which foreign matters are entrapped in the clearance or byproducts are deposited in any clearance by CVD process or the like, there is a concern in which the rotor can be instantaneously locked in a steady-state rotation at several ten thousands rotations per minute. Also, in the case of instantaneous locking, kinetic energy provided to the rotor constituting a high-speed rotating body having a large mass can become a torsional force applied toward the stator which would destroy the housing along with the stator."

To the contrary, in the present invention, (i) "a clearance is formed between said stator and said casing portion," (ii) "so that, when an abnormal torque is applied from said rotor to said stator, at least a part of said stator is allowed to rotate." Note that "said stator" corresponds to stator (3b) and "said casing portion" corresponds to housing (1) in JP6-40954. Thus, in the aspect of (i), the present invention is fundamentally different from JP6-40954.

The Examiner points out "fitting clearance near 5 formed between the stator 3b and casing portion 2"; however, JP6-40954 does not disclose such a "fitting clearance."

In JP6-40954, stator (3b) is supported by an upper ridge (1c) and a lower ridge (1d) of a tube-shaped supporting body (1a) constituting a portion of housing (1) slidably in a circumferential direction via sliding members (6a) and (6b) at an upper end face and a lower end face thereof. There is no "unnumbered fitting clearance near 5" between the stator (3b) and the casing portion (2). Although the Examiner regards the casing portion in JP6-40954 as reference numeral 2, reference numeral 2 represents a turbo-molecular pump section. The

casing portion of the present invention corresponds to housing (1) of JP6-40954. Thus, JP6-40954 does not disclose that "a clearance is formed between said stator and said casing portion, so that, when an abnormal torque is applied from said rotor to said stator, at least a part of said stator is allowed to rotate."

Reference numeral 1a in JP6-40954 represents a tube-shaped supporting body, constituting a part of housing, which corresponds to the stator of the present invention.

In addition, although the Examiner regards the member represented by reference numeral 3 as "inner casing", reference numeral 3 represents the spiral groove vacuum pump section, comprising a spiral-groove (3a) of a rotor (4) and a cylindrical stator (3b) facing the spiral groove (3a) with a very small clearance (5). Although the Examiner states, on page 9 of the Office Action, that the inner casing 3 surrounds the stator, with a small fitting clearance between the inner casing and the casing portion, there is no such small fitting clearance in JP6-40954.

The purpose of JP6-40954 is to avoid a pump operation failure due to foreign matters or byproducts entering into a very small clearance formed between rotor (4) and stator (3b). No clearance is formed between housing (1) and stator (3b) in JP6-40954. Specifically, when the problems described above occur, stator (3b) is allowed to rotate by such a structure that stator (3b) is supported by the upper ridge (1c) and the lower ridge (1d) of the tube-shaped supporting body (1a) slidably in a circumferential direction via sliding members (6a) and (6b).

Thus, JP6-40954 does not disclose that when an abnormal torque is applied from the

rotor to the stator, there is any clearance that would prevent the abnormal torque from being transmitted to the pump casing.

In JP6-40954, sliding members (6a) and (6b) are provided to make rotation of stator (3b) easier. These sliding members (6a) and (6b) are located on the top and bottom end surfaces of stator (3b) so that they are held against the top and bottom ridges (1c) and (1d) of the tube-shaped supporting body (1a) which constitutes a part of the housing. Thus, JP6-40954 neither discloses nor suggests any clearance at all which is intended to create an ultimate friction-free state "where no objects are in contact with each other" and to "prevent the force from being transmitted."

Accordingly, the present invention distinguishes over JP6-40954.

The undersigned declares that all statements made herein of his/her own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this 18th day of April, 2003

Matsutaro Miyamoto
Matsutaro MIYAMOTO